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METHODS OF ESTIMATING THE PHYSICAL AND CHEMICAL COMPOSITION OF CATTLE[1]

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INTRODUCTION

For certain practical purposes the relative fatness of cattle is commonly expressed as a specified degree of "condition" or "finish." Such personal judgment serves a need in marketing, but for research purposes fatness is best measured by knowledge of the chemical and physical composition of the live animal and of the carcass. Detailed analyses are laborious, costly, and often impractical. The purpose of this paper is to show that the composition of the entire animal and of the carcass can be predicted reliably from the analysis of only a small portion of the carcass.

REVIEW OF LITERATURE

Murray (*9*)[4] observed that the bodies of farm animals are composed of fat and nonfatty matter which varies within wide limits, depending on the feeding. For the animals studied, he noted that the percentage of chemical composition of the fat-free matter—moisture, ash, and protein—is practically the same and is not affected by the condition or the degree of fatness of the animal and to only a small extent by age.

Moulton (*4*) showed that the composition of animals should be compared on the fat-free basis and that the fatness of the individual has no effect on the composition calculated on the fat-free basis. Edema, underdevelopment, and atrophy were observed to give abnormal water percentages. He found that mammals reach chemical maturity at different ages and that these ages are a fairly constant part of the total life cycle. For cattle he observed that chemical maturity is reached at about 5 months after birth, after which time the chemical composition of the animal on the fat-free basis is a practical constant, showing but little decrease in water and but little increase in ash and protein percentages with advancing age.

Murray (*9*) stated that the chemical composition of the live animal may be estimated if the fatness is known, assuming a constant composition for the fat-free live animal body. Moulton, Trowbridge and

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[2] Appreciation must be expressed to the investigators of the Missouri Station for publication of the detailed data of their experiments. These data have done much to make the present study possible. The North Dakota steer data used were secured during the progress of a study on the fattening of steers on the short-grass range and subsequently in the feed lot. The principal workers on this project were J. T. Sarvis, U. S. Northern Great Plains Field Station, Mandan, N. Dak., and P. F. Trowbridge (deceased), E. J. Thompson, T. H. Hopper, Albert Severson, F. W. Christensen, L. L. Nesbitt, and A. J. Pinckney of the North Dakota Agricultural Experiment Station. Muriel Elledge made the mechanical calculations of the statistical analysis. The helpful criticisms and suggestions of A. Mason DuPré, Jr., and F. M. Wadley concerning the statistical treatment of the data are acknowledged.

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[4] Italic numbers in parentheses refer to Literature Cited, p. 267.

Haigh (*6*) when at the University of Missouri observed that for cattle the wholesale rib cut was representative of the carcass. Lush (*3*) studied various practical relations for estimating the proportion of fat and bone in cattle, using the published data of the Missouri, Illinois, Maine, and Rothamsted stations, and concluded that the percentage of fat in the edible portion (lean and fat flesh) of the wholesale rib cut is the more accurate indicator of the degree of fatness of the entire live animal.

Chatfield (*1*) found that "for any given wholesale cut there is a close relation between the content of fat determined as ether extract and that of the visible fat." Lush (*3*) found the relation between the ether extract in the edible portion of the wholesale rib cut and the ether extract in the entire live animal to be linear and to have a very high coefficient of correlation (+0.987). Lush noted that differences in sex and breed of the cattle slaughtered and differences in slaughter technique seemed to have less influence upon the wholesale rib cut as an indicator than upon the other indicators he studied.

In addition to the composition on the fat-free basis being a function of age in immature animals (*4*), it may be deducted that it is also a function of fatness in mature beef animals as Chatfield (*1*) concluded that the protein content of the edible portion of fresh mature beef sides is a curvilinear function of the fat content.

Lush (*3*) studied the relations referred to the entire live animal. The literature indicates, and recent results obtained at the North Dakota station show, that there is a large difference in the digestive fill or contents of the stomachs, intestines, and bladder, calculated as a percentage of the pasture or feed-lot live weight, influenced by the character of the ration consumed and possibly by the fatness of the animal. Sufficient data relative to these factors are not available to permit an estimate of the digestive fill or contents from knowledge of the ration consumed, but such data may be anticipated. Hence it appears that in working out indicator relations for the live animal they should be calculated to indicate the fatness of the warm empty body, that is, on the basis of the pasture or feed-lot live weight less the determined or estimated digestive fill or contents. The warm or "hot" carcass weight should also be used inasmuch as the chilled carcass weight is an empirical value depending on the washing loss and the losses of storage influenced by fatness and length of time of aging.

It has recently been suggested that the ninth, tenth, and eleventh rib portion of the wholesale rib cut is a more satisfactory or representative portion of the empty body and warm carcass than the wholesale rib cut. Hereafter in this presentation the ninth, tenth, and eleventh rib cut will be referred to as the 9–11 rib cut.

A study of the relations between the physical and chemical composition of the empty body, warm carcass, and edible portion of the warm carcass, and the physical and chemical composition of the whole and edible portions (lean and fat flesh) of the wholesale and 9–11 rub cuts was made.

THE BASIC DATA

It is obvious that the data avaiable for the study would be restricted to those experiments in which cattle were carefully slaughtered and the entire animal and certain parts fully accounted for in the physical and chemical analyses. Two groups of analyses were

found available. They were the published analyses of 33 steers and 3 cows from Missouri Agricultural Experiment Station bulletins (*5*, *6*, *7*, *8*, *10*, and *11*) and the unpublished analyses of 56 steers from the files of the North Dakota Agricultural Experiment Station. The slaughter record, carcass and wholesale rib-cut separation into lean, fat, and bone, and chemical analysis of empty body, carcass, and wholesale rib cut were found complete for 36 Missouri animals (28 steers from the "Use of Food" experiments, 5 steers from the "Retarded Growth" experiments, and 3 Jersey cows). For the North Dakota steers the available data included slaughter record, carcass, wholesale rib, and 9–11 rib separation into lean, fat, and bone, and chemical analysis of the 9–11 rib cut. The 9–11 rib cuts were further separated into eye muscle, other lean, fat, and bone for chemical analysis. The eye muscle is the longissimus dorsi taken without the superficial fascia or muscle lying outside the connective tissue. It represents clear lean or lean with only the fat of marbling.

The data for the Missouri animals were calculated to give the physical and chemical composition of the empty body, carcass, edible portion of carcass, wholesale rib cut, and edible portion of the wholesale rib cut. It was found necessary to calculate some of the percentages from the data in the original publications and to recalculate some others. In the calculations slaughter losses and shrinkages were considered as moisture and were so caluclated in recording the chemical composition and distributed proportionally between lean, fat, and bone in recording the physical composition.

The data for the North Dakota steers were calculated to give the physical composition of the empty body, whole and edible portions of the carcass, wholesale rib cut, and 9–11 rib cut, and the chemical composition of the whole and edible portion of the 9–11 rib cut.

In the tabulations and discussion of the date the term "fat" is used to represent the separable fatty adipose tissue. The term "ether extract" is used to represent the true chemical fat. For practical purposes it is assumed that moisture, ash, crude protein ($N \times 6.25$), and ether extract represent the total composition of the animal body and its several parts. In the physical composition of the empty body the lean included that of the carcass, head, and tail; the fat that of the carcass, head, tail, and offal (stomachs and intestines); the bone that of the carcass, head, tail, and feet; and the offal the rest of the animal body.

The basic data giving the age, weights, dressing percentages, and the physical and chemical composition are not presented in full detail. A summary of the data on the age, weights, dressing percentages, and physical composition is given in table 1, and of the chemical composition in table 2. These summary tables give the lowest and highest values, the range, the standard deviation, and the mean value for each of the various items of the basic data.

TABLE 1.—*Summary of data on age, weights, dressing percentages, and physical composition of the animals*

Item	Missouri animals (36)					North Dakota animals (56)					All animals (92)				
	Lowest value	Highest value	Range	Standard deviation (±)	Mean	Lowest value	Highest value	Range	Standard deviation (±)	Mean	Lowest value	Highest value	Range	Standard deviation (±)	Mean
Slaughter data:															
Age.....months	3	112	109	24.34	28.36	13	35	22	6.28	26.14	3	112	109	15.90	27.01
Live weight[1].....pounds	187	1,948	1,761	689.60	799.37	470	1,325	855	231.85	956.22	187	1,948	1,761	360.38	894.84
Empty-body weight.do	157	1,796	1,639	450.69	715.22	347	1,178	831	219.48	766.38	157	1,796	1,639	329.18	746.37
Warm-carcass weight.do	100	1,343	1,243	321.82	479.94	210	800	590	158.64	501.31	100	1,343	1,243	240.26	492.95
Digestive fill as percentage of live weight.....percent	6.74	17.72	10.98	2.76	11.60	11.08	31.56	20.48	5.59	20.71	6.74	31.56	24.82	6.46	17.14
Dressing percentage:															
Live-weight basis.do	53.00	70.42	17.42	4.55	57.75	43.11	61.15	18.04	4.92	51.51	43.11	70.42	17.31	5.65	53.95
Empty-body basis.do	58.82	75.52	16.70	3.75	65.27	60.52	69.52	9.00	2.30	64.97	58.82	75.52	16.70	2.93	65.08
Physical composition:															
Empty body:															
Lean.....do	31.92	48.10	16.18	3.86	41.94	35.99	46.80	10.81	2.59	41.09	31.92	48.10	16.18	3.16	41.42
Fat.....do	.73	40.13	39.40	10.04	14.17	3.06	29.43	26.37	6.91	14.28	.73	40.13	39.40	8.22	14.23
Bone.....do	9.38	26.47	17.09	4.34	16.84	11.08	19.84	8.72	2.37	15.59	9.38	26.47	17.09	3.32	16.08
Offal.....do	17.96	32.24	14.28	3.58	27.05	23.11	35.96	12.85	3.15	29.04	17.96	35.96	18.00	3.44	28.26
Carcass:															
Lean.....do	42.22	71.85	29.63	7.22	63.81	53.49	73.68	20.19	5.22	64.56	42.22	73.68	31.46	5.97	64.26
Fat.....do	.16	47.52	47.36	11.67	16.37	3.40	34.40	31.00	8.27	17.42	.16	47.52	47.36	9.69	17.01
Bone.....do	9.99	34.10	24.11	5.52	19.82	12.11	24.50	12.39	3.29	18.02	9.99	34.10	24.11	4.36	18.72
Edible portion of carcass:															
Lean.....percent	47.05	99.76	52.71	12.84	80.35	60.86	95.59	34.73	9.32	79.10	47.05	99.76	52.71	10.78	79.59
Fat.....do	.24	52.95	52.71	12.84	19.65	4.41	39.14	34.73	9.32	20.90	.24	52.95	52.71	10.78	20.41
Wholesale rib cut:															
Lean.....do	37.79	71.93	34.14	8.01	63.26	50.69	72.66	21.97	5.55	63.07	37.79	72.66	34.87	6.57	63.14
Fat.....do	0	50.76	50.76	13.14	12.62	2.18	37.23	35.05	9.02	16.32	0	50.76	50.76	11.90	14.87
Bone.....do	11.45	41.65	30.20	6.96	24.13	12.08	29.29	17.21	3.94	20.61	11.45	41.65	30.20	5.57	21.99
Edible portion of wholesale rib cut:															
Lean.....percent	42.68	100.00	57.32	15.01	84.53	57.65	96.99	39.34	10.41	79.91	42.68	100.00	57.32	12.54	81.72
Fat.....do	0	57.32	57.32	15.01	15.47	3.01	42.35	39.34	10.41	20.09	0	57.32	57.32	12.54	18.28
9–11 rib cut:															
Lean.....do						47.84	71.30	23.46	6.12	60.92					
Fat.....do						2.92	41.37	38.45	9.96	18.52					
Bone.....do						10.79	30.03	19.24	4.38	20.56					
Edible portion of 9–11 rib cut:															
Lean.....percent						53.62	95.97	42.35	11.43	77.25					
Fat.....do						4.03	46.38	42.35	11.43	22.75					

[1] Pasture or feed-lot live weight.

TABLE 2.—*Summary of data on the moisture, ash, crude protein, and ether extract content of the animals expressed on a percentage basis*

TABLE 2.—*Summary of data on the moisture, ash, crude protein, and ether extract content of the animals expressed on a percentage basis*

Animals and part analyzed	Moisture					Ash					Crude protein					Ether extract				
	Lowest value	Highest value	Range	Standard deviation (±)	Mean	Lowest value	Highest value	Range	Standard deviation (±)	Mean	Lowest value	Highest value	Range	Standard deviation (±)	Mean	Lowest value	Highest value	Range	Standard deviation (±)	Mean
Missouri animals (36):																				
Empty body	29.83	71.52	31.69	8.02	58.70	2.97	7.00	4.03	0.80	4.62	12.27	20.59	8.32	2.27	17.95	2.16	44.56	42.40	10.68	18.14
Carcass	36.77	71.72	34.95	8.89	57.04	3.03	8.26	5.23	1.01	5.16	10.22	19.92	9.70	2.46	17.35	2.20	49.83	47.63	11.96	20.45
Edible carcass	37.20	77.25	40.15	10.82	62.10	.48	1.16	.68	.16	.86	9.00	19.98	10.98	2.81	16.93	1.89	53.32	51.43	13.71	20.11
Wholesale rib	31.22	71.74	40.52	9.87	55.74	3.57	9.92	6.35	1.36	6.34	10.13	21.32	11.19	2.86	17.78	2.41	55.08	52.67	13.40	20.12
Edible wholesale rib	31.03	77.28	46.25	12.34	61.98	.41	1.16	.75	.19	.86	8.74	20.71	11.97	3.21	17.09	2.09	59.82	57.73	15.66	20.08
North Dakota animals (56):																				
9–11 rib	37.97	67.29	29.32	7.83	53.39	4.39	9.08	4.69	1.16	6.70	13.09	22.72	9.63	2.31	18.46	2.68	44.55	41.87	10.91	21.45
Edible 9–11 rib	39.18	76.45	37.27	9.97	58.81	.57	1.09	.52	.13	.84	11.67	21.91	10.24	2.51	17.22	1.84	48.58	46.74	10.57	23.13
Fat of 9–11 rib	8.34	67.72	59.38	15.73	22.82	.15	1.02	.87	.22	.38	2.65	15.78	13.13	3.57	7.35	16.18	88.86	72.68	19.32	69.75
Bone of 9–11 rib	23.76	46.52	22.76	5.08	33.18	22.69	36.59	13.90	3.31	29.72	21.19	25.90	4.71	.89	23.62	4.13	20.26	16.13	3.55	12.81
Eye muscle, 9–11 rib	70.40	78.28	7.88	1.86	74.56	1.00	1.16	.16	.03	1.06	20.44	22.99	2.55	.47	21.64	.39	6.74	6.35	1.53	2.60

DISCUSSION OF ANIMALS AND METHODS

The data available for study gave a wide variation in the breeding, age, weight, and fatness of the animals. The ages ranged from 3 to 112 months at the time of slaughter, the empty-body weight from 157 to 1,796 pounds, and ether extract in the empty body from 2.2 to 44.6 percent. Aside from the 3 aged Jersey cows, the animals were of the beef-type breeds and their crosses. The 33 Missouri steers included purebred Herefords, and Shorthorns, and Hereford-Shorthorn crosses. Their ages ranged from 3 to 48 months. The ages of the cows were 76, 85, and 112 months respectively. The 56 North Dakota steers included animals from 4 groups used in the range-grazing and lot-feeding experiments. They were range-reared Herefords of apparently good breeding and ranged from 13 to 35 months in age. Two of these groups of steers were obtained from western North Dakota ranches, one from Canada, and the fourth was purchased on the feeder market at Kansas City, Mo.

The advisability of using the empty-body weight instead of the feed-lot, pasture, or slaughter live weight is evident from the variations in the percentage of digestive fill (table 1), which are certainly influenced by the character of the ration and possibly by the weight and fatness of the animal. The digestive fill is thought to be best expressed as a percentage of the feed-lot or pasture live weight. The variation is striking in the case of the North Dakota steers. The percentages for the steers grazing on the native short-grass pasture averaged 25.2, 24.1, 19.1, and 27.5 for the grazing seasons of 1933, 1934, 1935, and 1936 respectively. The low average value for 1935 may be accounted for by the fact that the pasturage available was all new growth and of good quality. The range pasture had been grazed bare the previous season. The high value for 1936 may have resulted from the poor quality and fibrous nature of the pasturage carried over from 1935. As a result of drought there was practically no growth of vegetation in 1936. In the feed lot on grain-fattening rations steers from the same groups averaged 14.0, 14.4, 13.7, and 17.3 percent of digestive fill respectively. The higher average value of 17.3 for the 1936 group was perhaps due to the feeding of light-weight barley, high in crude fiber. For the animals studied the digestive fill ranged from 6.74 to 31.56 percent of the pasture or feed-lot live weight.

The data on the physical and chemical composition have been used as a basis for the calculation by the method of least squares of linear equations which might be of use in estimating the composition of the empty body, carcass, and edible carcass from the rib cuts. The statistical formulae (*2*, *12*) used were:

$$\text{Standard deviation} = \sigma_x = \sqrt{\frac{\Sigma(x^2) - \frac{(\Sigma x)^2}{n}}{n-1}}$$

$$\text{Standard error of mean} = \frac{\sigma_x}{\sqrt{n}}$$

$$\text{Correlation coefficient} = r_{xy} = \frac{\Sigma(xy) - \frac{(\Sigma x)(\Sigma y)}{n}}{\sqrt{\left[\Sigma(x^2) - \frac{(\Sigma x)^2}{n}\right]\left[\Sigma(y^2) - \frac{(\Sigma y)^2}{n}\right]}}$$

$$\text{Standard error of estimate} = S_{yx} = \sqrt{\frac{\Sigma(y^2) - \frac{(\Sigma y)^2}{n}}{n-2}(1-r^2_{xy})}$$

$$\text{Partial correlation coefficient} = r_{xa \cdot b} = \frac{r_{xa} - (r_{xb})(r_{ab})}{\sqrt{(1-r^2_{xb})}\sqrt{(1-r^2_{ab})}}$$

The probable error of estimate was not calculated. If desired, it may be considered as being two-thirds of the standard error of estimate. The formulae are given in expanded forms which when used for machine calculation introduce the least mechanical error.

As is evident, some of the correlation coefficients are of a part correlated with the whole. This does not invalidate the use of the regression equations for prediction, but does invalidate the usual tests of significance whose purpose is to detect small differences between correlation coefficients derived from such data. However, if a small part shows a correlation with the whole of 0.98, for example, and another such correlation has a value of 0.96, both should be considered about equally reliable. Further when one such value is 0.98 and another is 0.75 it seems likely that the difference is a real one if the series are fairly large. In this paper emphasis is given to the standard errors of estimate as a measure of the usefulness of the regression equations for prediction purposes. As a consequence, correlation coefficients are used but sparingly in judging the value of the regression relations, but are included in the tables for the interest of the general reader.

RELATIONS IN PHYSICAL COMPOSITION

The relations calculated between the percentages of lean, fat, and bone in the rib cuts and the percentages of lean, fat, and bone in the empty body, carcass, and the edible portion of the carcass were found to have high positive correlation coefficients and the regressions appear to be linear (table 3).

The percentage fat relations, in which most interest is centered, have particularly high coefficients, +0.97 or higher, and relatively low standard errors of estimate and should be satisfactory for prediction purposes.

The relations for the estimation of the lean in the empty body have lower correlation coefficients than those for the estimation of the fat but the standard errors of estimate are relatively low considering the percentage of lean in the empty body. It must be noted that practically all of the lean in the empty body is accounted for in the carcass portion of the body and that there is considerable variability in the percentage of the offal and its parts, such as the head, feet, and hide. This variability may be illustrated by citing an observation of the variation in the hide weight from 82 to 132 pounds (average 101.6 pounds) per steer for 30 Hereford steers averaging 1,135 pounds slaughter live eight and slaughtered on the same date.

The relations for the estimation of the lean in the carcass and edible portion of the carcass (table 3) have correlation coefficients of high order, ranging from +0.88 to +0.98. The 9–11 rib cut appears to be the better indicator on the basis of standard errors of estimate. For the edible portion of the carcass the edible portion of the rib cuts

TABLE 3.—*Relations in Physical Constituents*

Relation No.	X	Y	n	r_{xy}	Regression of Y on X	
					Equation	S_{yx} (±)
1	Lean, wholesale rib	Lean, empty body	92	0.841	Y=0.40422 X+15.89934	1.714
2	Lean, edible wholesale rib	do	92	.804	Y= .20264 X+24.86306	1.885
3	Lean, 9–11 rib	do	56	.715	Y= .30270 X+22.65161	1.827
4	Lean, edible 9–11 rib	do	56	.728	Y= .16522 X+28.32942	1.791
5	Fat, wholesale rib	Fat, empty body	92	.973	Y= .73396 X+ 3.31928	1.900
6	Fat, edible wholesale rib	do	92	.970	Y= .63594 X+ 2.60774	2.006
7	Fat, 9–11 rib	do	56	.985	Y= .68371 X+ 1.61401	1.180
8	Fat, edible 9–11 rib	do	56	.981	Y= .59276 X+ .79290	1.345
9	Bone, wholesale rib	Bone, empty body	92	.965	Y= .57309 X+ 3.43707	.874
10	Bone, 9–11 rib	do	56	.947	Y= .51327 X+ 5.04322	.764
11	Lean, wholesale rib	Lean, carcass	92	.958	Y= .88148 X+ 8.60471	1.745
12	Lean, edible wholesale rib	do	92	.929	Y= .44873 X+27.59468	2.241
13	Lean, 9–11 rib	do	56	.940	Y= .80173 X+15.71220	1.784
14	Lean, edible 9–11 rib	do	56	.960	Y= .43838 X+30.69027	1.470
15	Fat, wholesale rib	Fat, carcass	92	.981	Y= .87296 X+ 4.02921	1.857
16	Fat, edible wholesale rib	do	92	.980	Y= .75784 X+ 3.15617	1.920
17	Fat, 9–11 rib	do	56	.984	Y= .81774 X+ 2.27664	1.459
18	Fat, edible 9–11 rib	do	56	.982	Y= .71026 X+ 1.26501	1.574
19	Bone, wholesale rib	Bone, carcass	92	.974	Y= .76344 X+ 1.94001	.983
20	Bone, 9–11 rib	do	56	.941	Y= .70750 X+ 3.47863	1.120
21	Lean, wholesale rib	Lean, edible carcass	92	.880	Y=1.44356 X−11.56371	5.142
22	Lean, edible wholesale rib	do	92	.979	Y= .84248 X+10.74122	2.185
23	Lean, 9–11 rib	do	56	.940	Y=1.43280 X− 8.19347	3.185
24	Lean, edible 9–11 rib	do	56	.982	Y= .80161 X+17.17102	1.748
25	Fat, wholesale rib	Fat, edible carcass	92	.978	Y= .96820 X+ 6.01490	2.239
26	Fat, edible wholesale rib	do	92	.979	Y= .84248 X+ 5.01078	2.185
27	Fat, 9–11 rib	do	56	.983	Y= .92088 X+ 3.84738	1.727
28	Fat, edible 9–11 rib	do	56	.982	Y= .80161 X+ 2.66798	1.748
29	Lean, edible wholesale rib	Lean, wholesale rib	92	.908	Y= .47676 X+24.18313	2.759
30	Lean, 9–11 rib	do	56	.967	Y= .87618 X+ 9.69149	1.422
31	Lean, edible 9–11 rib	do	56	.949	Y= .46068 X+27.48255	1.762
32	Lean, 9–11 rib	Lean, edible wholesale rib	56	.958	Y=1.62919 X−19.34614	2.997
33	Lean, edible 9–11 rib	do	56	.988	Y= .90004 X+10.37911	1.601
34	do	Lean, 9–11 rib	56	.970	Y= .51978 X+20.76896	1.498
35	Fat, edible wholesale rib	Fat, wholesale rib	92	.998	Y= .86778 X− .99375	2.010
36	Fat, 9–11 rib	do	56	.989	Y= .89609 X− .27648	1.302
37	Fat, edible 9–11 rib	do	56	.985	Y= .77710 X− 1.35747	1.538
38	Fat, 9–11 rib	Fat, edible wholesale rib	56	.988	Y=1.03403 X+ .93973	1.570
39	Fat, edible 9–11 rib	do	56	.988	Y= .90004 X− .38311	1.601
40	do	Fat, 9–11 rib	56	.997	Y= .86890 X− 1.24474	.667
41	Bone, 9–11 rib	Bone, wholesale rib	56	.974	Y= .87830 X+ 2.55467	.894

should be a more reliable indicator than the whole rib cuts as the relations have lower standard errors of estimate.

As indicators of fatness the whole and edible portions of the wholesale and 9–11 rib cuts all appear to be quite reliable (table 3). The regression coefficients are all less than one, showing a greater fatness in the rib cuts than in the gross portions. The range in the *Y* intercepts of the relations for each of the gross portions is not excessive, and the results estimated by the equations from the percentage of fat in the several rib cuts used as indicators should not vary greatly except at the limits of the range in the fatness of the animals.

The relations for the prediction of the bone (table 3) in the empty body and carcass from the wholesale and 9–11 rib cuts are linear and have correlation coefficients higher and standard errors of estimate lower than was anticipated on account of individual characteristics. The coefficients for the wholesale rib relation are the higher but on the basis of the *Y* intercepts and the standard errors of estimate the two cuts are of about equal value for prediction usage.

The relationship between the rib cuts in the percentages of the physical constituents is quite high (table 3 relations 29–41) especially for the fat. In percentage of fat between the whole and edible portions the correlations were +0.998 for the wholesale rib cut and +0.997 for the 9–11 rib cut. Hence the whole and edible portions should serve equally well as fatness indicators especially in the case of the 9–11 rib cut where the standard error of estimate was but ±0.667.

RELATIONS IN CHEMICAL COMPOSITION

The chemical composition—percentages of moisture, ash, crude protein ($N\times6.25$) and ether extract—of the whole and of the edible portions of the wholesale rib cut is highly correlated with that of the empty body carcass and edible portion of the carcass (table 4). As the correlation coefficients are all very high and the standard errors of estimate relatively small the relations should be of value for prediction purposes using the composition of the whole or edible portion of the wholesale rib cut as the indicator. The chemical composition of the edible portions of the wholesale and 9–11 rib cuts is highly correlated with that of the corresponding whole portions (table 4).

TABLE 4.—*Relations in chemical constituents*

Relation No.	X	Y	n	r_{xy}	Regression of Y on X	
					Equation	S_{yx} (±)
1	Moisture, wholesale rib	Moisture, empty body	36	0.984	$Y=0.79070\ X+14.12032$	1.446
2	Ash, wholesale rib	Ash, empty body	36	.925	$Y=.54723\ X+1.14747$	.308
3	Crude protein, wholesale rib.	Crude protein, empty body.	36	.948	$Y=.75400\ X+4.53862$	.731
4	Ether extract, wholesale rib.	Ether extract, empty body.	36	.992	$Y=.79149\ X+2.20772$	1.311
5	Moisture, edible wholesale rib.	Moisture, empty body	36	.985	$Y=.64010\ X+19.02780$	1.377
6	Crude protein, edible wholesale rib.	Crude protein, empty body.	36	.943	$Y=.66837\ X+6.52389$	.762
7	Ether extract, edible wholesale rib.	Ether extract, empty body.	36	.989	$Y=.67616\ X+4.56741$	1.532
8	Moisture, wholesale rib	Moisture, carcass	36	.991	$Y=.89311\ X+7.25137$	1.198
9	Ash, wholesale rib	Ash, carcass	36	.953	$Y=.71345\ X+.63730$	.312
10	Crude protein, wholesale rib.	Crude protein, carcass	36	.985	$Y=.84942\ X+2.24676$	.420
11	Ether extract, wholesale rib.	Ether extract, carcass	36	.994	$Y=.88736\ X+2.58567$	1.217
12	Moisture, edible wholesale rib.	Moisture, carcass	36	.990	$Y=.71318\ X+12.83667$	1.253
13	Crude protein, edible wholesale rib.	Crude protein, carcass	36	.981	$Y=.75323\ X+4.47855$	.480
14	Ether extract, edible wholesale rib.	Ether extract, carcass	36	.992	$Y=.75817\ X+5.22898$	1.493
15	Moisture, wholesale rib	Moisture, edible carcass.	36	.983	$Y=1.07820\ X+2.00290$	2.006
16	Crude protein, wholesale rib.	Crude protein, edible carcass.	36	.985	$Y=.96686\ X-.26467$	.489
17	Ether extract, wholesale rib.	Ether extract, edible carcass.	36	.993	$Y=1.01546\ X-.33524$	1.641
18	Moisture, edible wholesale rib.	Moisture, edible carcass.	36	.993	$Y=.87065\ X+8.14647$	1.263
19	Crude protein, edible wholesale rib.	Crude protein, edible carcass.	36	.985	$Y=.86146\ X+2.20579$	.483
20	Ether extract, edible wholesale rib.	Ether extract, edible carcass.	36	.994	$Y=.87116\ X+2.61859$	1.456
21	Moisture, edible wholesale rib.	Moisture, wholesale rib.	36	.992	$Y=.79327\ X+6.58009$	1.218
22	Crude protein, edible wholesale rib.	Crude protein, wholesale rib.	36	.994	$Y=.88567\ X+2.64602$	.308
23	Ether extract, edible wholesale rib.	Ether extract, wholesale rib.	36	.997	$Y=.85450\ X+2.97706$	.953
24	Moisture, edible 9–11 rib	Moisture, 9–11 rib	56	.994	$Y=.78144\ X+7.43330$	.793
25	Crude protein, edible 9–11 rib.	Crude protein, 9–11 rib.	56	.997	$Y=.91536\ X+2.69842$	.174
26	Ether extract, edible 9–11 rib.	Ether extract, 9–11 rib	56	.998	$Y=.86782\ X+1.37632$	.523

RELATIONS BETWEEN CHEMICAL AND PHYSICAL CONSTITUENTS

The study of the relations between chemical and physical constituents was limited almost entirely to fatness. It is an observation of practical importance that very high correlation coefficients and relatively low standard errors of estimate were found for the relations between separable fat and ether extract. This is true for all portions examined, namely, empty body, carcass, edible portion of the carcass, wholesale rib, edible wholesale rib, 9–11 rib, and edible 9–11 rib. The relations for the empty body carcass, and edible portion of the carcass are illustrated in figure 1.

The relations between the ether extract in the whole and edible portions of the 9–11 rib cuts and the fat in the empty body, carcass, and edible carcass (table 5 relations 8–13) are very satisfactory, having correlation coefficients ranging from +0.987 to +0.989 and standard errors of estimate from ±1.11 to ±1.41. Figure 2 shows graphically the relations between the 9–11 rib cut and the three gross portions.

TABLE 5.—*Relations between chemical and physical constituents*

Relation No.	X	Y	n	r_{xy}	Regression of Y on X	
					Equation	$S_{y.x}(\pm)$
1	Fat, empty body	Ether extract, empty body.	36	0.996	$Y=1.06089\ X+3.11131$	0.954
2	Fat, carcass	Ether extract, carcass	36	.994	$Y=1.01885\ X+3.76039$	1.291
3	Fat, edible carcass	Ether extract, edible carcass.	36	.994	$Y=1.06206\ X-.76254$	1.455
4	Fat, wholesale rib	Ether extract, wholesale rib.	36	.988	$Y=1.00834\ X+7.40977$	2.076
5	Fat, edible wholesale rib	Ether extract, edible wholesale rib.	36	.990	$Y=1.03356\ X+4.08890$	2.140
6	Ether extract, 9–11 rib	Fat, 9–11 rib	56	.992	$Y=.90486\ X-.88734$	1.241
7	Ether extract, edible 9–11 rib.	Fat, edible 9–11 rib	56	.994	$Y=.90454\ X+1.82599$	1.230
8	Ether extract, 9–11 rib	Fat, empty body	56	.986	$Y=.62433\ X+.88575$	1.121
9	do	Fat, carcass	56	.988	$Y=.74878\ X+1.36142$	1.249
10	do	Fat, edible carcass	56	.988	$Y=.84457\ X+2.78782$	1.410
11	Ether extract, edible 9–11 rib.	Fat, empty body	56	.987	$Y=.84260\ X+1.72666$	1.106
12	do	Fat, carcass	56	.988	$Y=.65064\ X+2.37270$	1.241
13	do	Fat, edible carcass	56	.989	$Y=.73420\ X+3.92085$	1.372
14	Fat, edible wholesale rib	Ether extract, wholesale rib.	36	.989	$Y=.88448\ X+6.45086$	1.928
15	Ether extract, 9–11 rib	Fat, edible 9–11 rib	56	.992	$Y=1.03899\ X+.46270$	1.434
16	Ether extract, edible 9–11 rib.	Fat, 9–11 rib	56	.993	$Y=.78684\ X+.32139$	1.166
17	Ether extract, eye muscle, 9–11 rib.	Fat, empty body	56	.900	$Y=4.06166\ X+3.73293$	3.037
18	do	Fat, carcass	56	.894	$Y=4.83503\ X+4.87026$	3.722
19	do	Fat, edible carcass	56	.891	$Y=5.42977\ X+6.80732$	4.272
20	Ether extract, fat, 9–11 rib.	Ether extract, 9–11 rib	56	.891	$Y=.50385\ X-13.69504$	4.994
21	do	Ether extract, edible 9–11 rib.	56	.892	$Y=.58068\ X-17.37301$	5.720
22	Ether extract, bone, 9–11 rib.	Ether extract, 9–11 rib	56	.676	$Y=2.07738\ X-5.16224$	8.113
23	do	Ether extract, edible 9–11 rib.	56	.658	$Y=2.32610\ X-6.66734$	9.549
24	Bone, empty body	Ash, empty body	36	.712	$Y=.13204\ X+2.39445$	.572
25	Bone, carcass	Ash, carcass	36	.678	$Y=.12516\ X+2.68145$	.759

As should be expected, excellent correlations exist between the percentage of fat in the rib cuts and the ether extract in the corresponding whole or edible portion (table 5, relations 14–16).

Though the correlations found are high, the ether extract of the eye muscle and the separable fat of the 9–11 rib cut are not considered as reliable indicators of fatness (table 5, relations 17–21) as the separable fat and ether extract of the rib cuts. The standard errors of

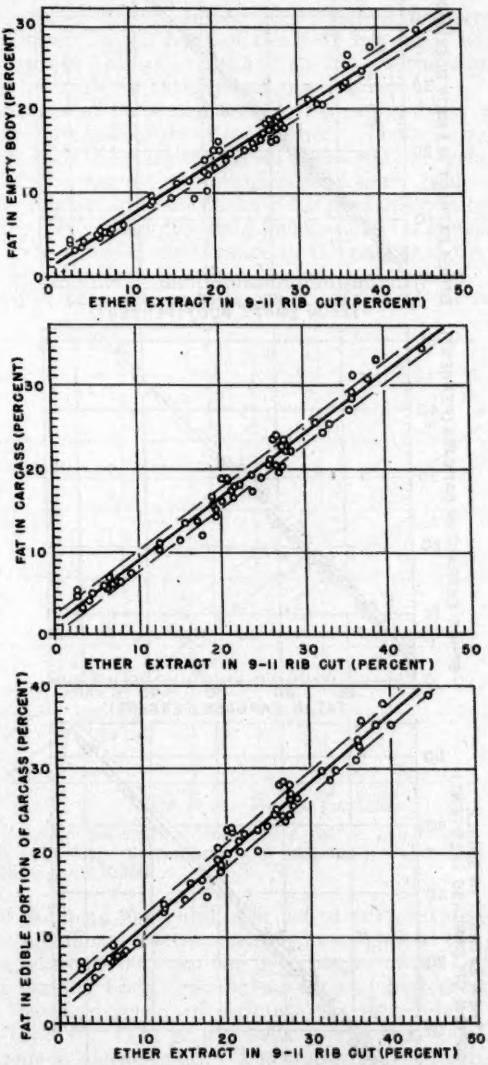
FAT IN EMPTY BODY (PERCENT)
ETHER EXTRACT IN 9-11 RIB CUT (PERCENT)
FAT IN CARCASS (PERCENT)
ETHER EXTRACT IN 9-11 RIB CUT (PERCENT)
FAT IN EDIBLE PORTION OF CARCASS (PERCENT)
ETHER EXTRACT IN 9-11 RIB CUT (PERCENT)

FIGURE 1.—Relations between the percentages of fat and ether extract in the empty body, carcass, and edible portion of carcass (36 Missouri steers and cows). Empty body: $Y=1.06089\ X+3.11131$; $r_{xy}=+0.996$; $S_{yx}=\pm 0.954$. Carcass: $Y=1.01885\ X+3.76939$; $r_{xy}=+0.994$; $S_{xy}=\pm 1.291$. Edible carcass: $Y=1.06206\ X-0.76254$; $r_{xy}=+0.994$; $S_{yx}=\pm 1.455$.

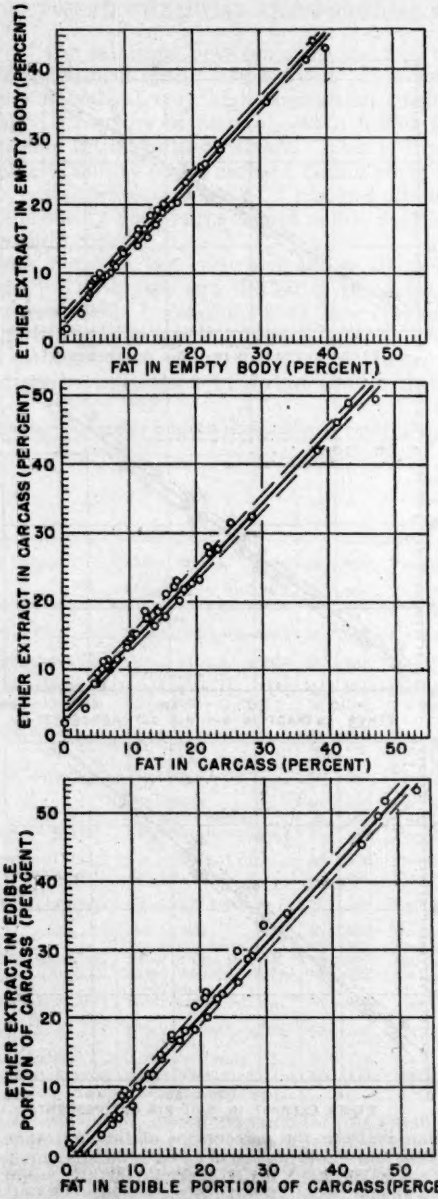

FIGURE 2.—Relations between the percentages of ether extract in the 9–11 rib cut and fat in empty body, carcass, and edible carcass (56 North Dakota steers). Empty body: $Y=0.62433\ X+0.88575$; $r_{xy}=+0.986$; $S_{yz}=\pm 1.121$. Carcass: $Y=0.74878\ X+1.36142$; $r_{xy}=+0.988$; $S_{yz}=\pm 1.249$. Edible carcass: $Y=0.84457\ X+2.78782$; $r_{xy}=+0.988$; $S_{yz}=\pm 1.410$.

estimate are high. A narrow range in ether extract (6.35) in the eye muscle corresponded to a relatively wide range in fat in the empty body (26.37), carcass (31.00), and edible portion of the carcass (34.73).

The ether extract in the bone of the 9–11 rib cut is not a reliable indicator of fatness (table 5, relations 22–23), as the standard error of estimate is too high for satisfactory prediction.

The percentages of bone and ash in the empty body and carcass are not satisfactory indicators of each other. Though the correlation coefficients are high the standard errors of estimate are relatively large proportions of the respective substances present (table 5, relations 24–25) for the relations to be adequate for prediction purposes.

The dressing percentage has long been used as a general indicator of fatness. It has special significance to the packer in his operations. However, it is a function of other factors than fatness. Individual and breed differences in percentages of offal and its constituents,

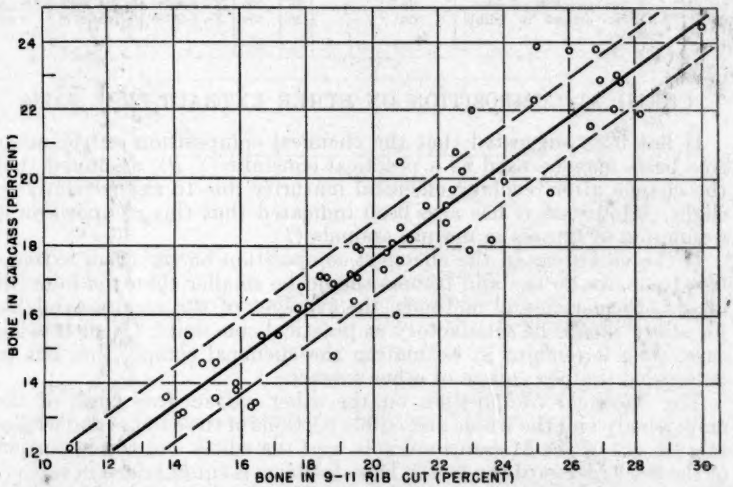

FIGURE 3.—Relation between percentage of fat in the empty body and the empty-body dressing percentage (92 anlmals): $Y=0.25541X+61.44850$; $r_{xy}=+0.716$; $S_{yx}=\pm 2.055$.

especially of the head, feet, and hide, are of material significance. Of even greater significance are variations in weights of the digestive fill. Though the relations between the percentages of fat and of ether extract and the empty body dress have relatively high correlation coefficients, the standard errors of estimate are rather high for accurate prediction (table 6). The empty-body weight has been used to eliminate variations in digestive fill. The empty-body dressing percentage used is the percentage of warm carcass of the empty body. Only the simple correlations were calculated. It is noted that wide ranges in fatness occur for the same dressing percentages (fig. 3), and it must follow that when used, the dressing percentage may only be considered a general indicator for wide ranges in fatness.

TABLE 6.—*Relations between fatness and empty-body dressing percentage*

Relation No.	X	Y	n	r_{xy}	Equation	S_{yx} (±)
	Regression of Y on X:					
1a	Fat in empty body	Empty-body dress	92	0.716	$Y=0.25541\ X+61.44850$	2.055
2a	Fat in carcass	do	92	.714	$Y=\ .21592\ X+61.41082$	2.062
3a	Fat in edible carcass	do	92	.707	$Y=\ .19231\ X+61.15838$	2.081
4a	Ether extract in empty body.	do	36	.705	$Y=\ .24734\ X+60.77816$	2.695
5a	Ether extract in carcass	do	36	.709	$Y=\ .22238\ X+60.71873$	2.680
6a	Ether extract in edible carcass.	do	36	.699	$Y=\ .19114\ X+60.42296$	2.718
						S_{xy} (±)
	Regression of X on Y:					
1b	Fat in empty body	do	92	.716	$X=2.00981\ Y-116.57247$	5.765
2b	Fat in carcass	do	92	.714	$X=2.36219\ Y-136.72977$	6.821
3b	Fat in edible carcass	do	92	.707	$X=2.60502\ Y-149.13212$	7.659
4b	Ether extract in empty body.	do	36	.705	$X=2.01179\ Y-113.16029$	7.685
5b	Ether extract in carcass	do	36	.709	$X=2.26304\ Y-127.25047$	8.548
6b	Ether extract in edible carcass.	do	36	.699	$X=2.55730\ Y-146.79776$	9.942

CHEMICAL COMPOSITION ON ETHER EXTRACT-FREE BASIS

It has been suggested that the chemical composition on the ether free basis may be used as a practical constant (*4*, *9*), assuming that the change after reaching chemical maturity due to age is relatively slight. However, it has also been indicated that this composition is a function of fatness in mature animals (*1*).

If the variations in the chemical composition on the ether extract-free basis due to age and fatness should be smaller than the inherent errors of experimental methods, the averages of the results available for study should be satisfactory as practical constants. If such is the case, then it remains in estimating the chemical composition but to determine the percentage of ether extract.

The chemical composition on the ether extract-free basis of the empty body and the whole and edible portions of the carcass and wholesale rib cut of the Missouri animals, and the whole and edible portion of the 9–11 rib cut of the North Dakota steers is summarized in table 7. The statistical analysis of the data is given in the same table. Considering the wide variations in age, weight, fatness, and breeding of the Missouri animals, the variations observed are relatively small, especially in the edible portions.

The relation between the ether extract-free composition and age in months is shown graphically in figure 4 for each of the three major portions of the animal. The lines drawn represent the means and the regression equations. That there is a slight decrease in moisture and increase in ash and protein with age is indicated by the graphs. The ash, however, in the edible portion of the carcass varies so slightly that the mean should be better than a practical constant. The data for the three aged Jersey cows appear to conform in general to the change-with-age tendency in the carcass and edible portion of the carcass but not in the case of the empty body.

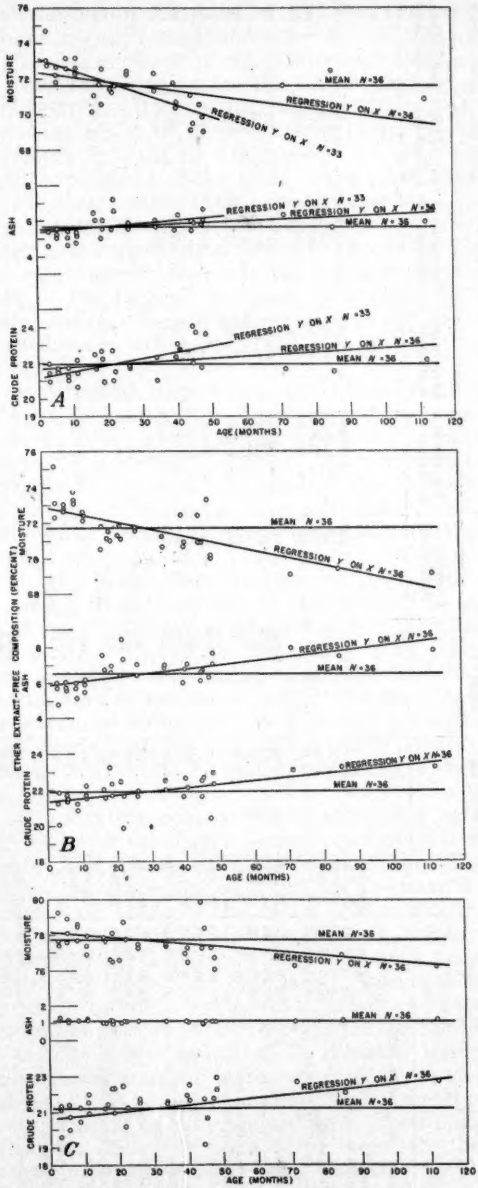

FIGURE 4.—Relation between chemical composition on the ether extract-free basis of the empty body (*A*), carcass (*B*), and edible portion of the carcass (*C*), and age in months. The lines represent the means and the regression equations tables 7 and 8).

TABLE 7.—*Range in and mean of ether extract-free chemical composition and correlation of this composition with age in months of animals and fatness (percentage of ether extract)*

	Range	Mean	Standard error of mean (±)	Standard deviation (±)	Simple correlation				Partial correlation	
					With age (months)		With percent ether extract		With age (months)	With percent ether extract
					Correlation coefficient	Regression coefficient [1]	Correlation coefficient	Regression coefficient [2]	Correlation coefficient	Correlation coefficient
Missouri steers and cows (36 animals):										
Empty body:	*Percent*	*Percent*								
Moisture	69.02–74.74	71.662	0.205	1.245	−0.480	−0.02456	−0.280	−0.03266	−0.408	−0.048
Ash	4.49– 7.15	5.637	.096	.580	+.431	+.01027	−.046	−.00254	+.528	−.341
Crude protein	20.57–24.00	21.951	.138	.838	+.367	+.01264	+.225	+.01767	+.301	+.048
Moisture: protein ratio	2.88– 3.57	3.270	.028	.170	−.424	−.00296	−.264	−.00420	−.349	−.062
Carcass:										
Moisture	69.06–75.13	71.665	.220	1.337	−.740	−.04072	−.174	−.01953	−.763	−.321
Ash	4.83– 8.44	6.491	.134	.813	+.617	+.02064	+.025	+.00170	+.694	−.403
Crude protein	19.78–23.23	21.843	.136	.829	+.589	+.02008	+.257	+.01783	+.549	−.044
Moisture: protein ratio	2.97– 3.75	3.287	.030	.180	−.576	−.00428	−.239	−.00362	−.542	−.059
Edible portion of carcass:										
Moisture	76.20–79.69	77.721	.130	.795	−.572	−.01870	−.122	−.00709	−.593	−.224
Ash	.94– 1.23	1.069	.010	.061	−.142	−.00036				
Crude protein	19.28–22.70	21.210	.129	.789	+.588	+.01906	+.146	+.00844	+.599	−.203
Moisture: protein ratio	3.36– 4.13	3.669	.028	.174	−.559	−.00402	−.131	−.00168	−.573	+.199
Wholesale rib cut:										
Moisture	66.29–74.53	69.714	.291	1.769						
Ash	5.30–10.28	7.987	.209	1.274						
Crude protein	20.17–23.65	22.299	.136	.827						
Edible portion of wholesale rib:										
Moisture	76.03–79.93	77.504	.145	.884						
Ash	.91– 1.24	1.069	.012	.071						
Crude protein	19.16–22.91	21.427	.145	.880						
North Dakota steers (56 animals):										
9–11 rib cut:										
Moisture	65.21–70.20	67.908	.210	1.263						
Ash	6.58–10.50	8.543	.164	.992						
Crude protein	21.62–24.60	23.549	.098	.593						
Edible portion of 9–11 rib cut:										
Moisture	75.23–78.26	76.435	.108	.649						
Ash	1.03– 1.16	1.098	.005	.029						
Crude protein	20.62–23.61	22.467	.106	.637						

[1] Regression of composition on age in months.
[2] Regression of composition on percent ether extract.

Simple correlations of the ether extract-free composition with age in months have negative coefficients for the percentage of moisture (table 7). The ash coefficients are positive for the empty body and carcass but they are negative for the edible portion of the carcass. The crude protein coefficients are positive. The regression coefficients of the composition on age are too small for the relations to be highly satisfactory for prediction purposes.

The simple correlations of the ether extract-free composition with the percent of ether extract in the original portions have regression coefficients in most cases which are insignificantly small (table 7).

Partial correlation coefficients (table 7) calculated for the relation between the ether extract-free composition and age and percentage ether extract in the original portions show that the tendency for change in composition is largely attributable to age and not to fatness. The partial coefficients with age are negative for moisture and positive for ash and protein.

Some have attached importance to the moisture-protein ratio. With a tendency for percentage of moisture to decrease and percentage of protein to increase with age there should be a decrease in the ratio with age. The standard errors of the means and the standard deviations (table 7) are relatively small. The ratios are negatively correlated with age. The regression coefficients of the ratios on age are relatively quite small. Partial correlation of the ratios gives negative coefficients with age.

Murray (*9*) concluded that the ratio of protein to ash does not alter with the age of the animal but that it may be influenced to a certain extent by the food, and he gave the mean value of the ratio for his data as 4.392 ± 0.215 for the empty body. For the present data (36 animals) the ratio ranged from 2.94 to 4.70 and averaged 3.93 with a standard deviation of ± 0.371 for the empty body. For the carcass it ranged from 2.91 to 4.18 and averaged 3.41 with a standard deviation of ± 0.388 and for the edible portion of the carcass it ranged from 16.82 to 22.31 and averaged 19.90 with a standard deviation of $+1.26$.

It was noted that the composition on the ether extract-free basis of the empty body for the 3 aged Jersey cows did not conform to the continuation of the change in composition of the 33 steers (fig. 4). For this reason the statistical data for the 33 steers were calculated for comparison with those of the entire group including the 3 cows (table 8). There are but small differences in means and standard deviations between the 2 groups. For the empty body, the correlation coefficients are higher, the regression coefficients higher, and the standard errors of estimate lower for the group of 33 steers. For the carcass and edible portion of the carcass the correlation coefficients are higher for the entire group of 36 animals, though there were rather small differences in the regression coefficients and the standard errors of estimate. It is noted that there is but small reduction from the standard deviation to the standard error of estimate.

Composition on the ether extract-free basis may be considered a practical constant for some purposes. However, to a certain extent it is a function of age. Using the regression of the composition on age, the composition at 10, 20, 30, 40, and 50 months of age was calculated (table 9) for the 33 steers and also for the 36 steers and cows.

The data and the graphs (fig. 4) indicate that the results calculated according to the regression should have practical use in estimating the chemical composition when the fatness determined as ether extract is known.

TABLE 8.—*Comparison of statistical analysis of composition on the ether extract-free basis of the 33 steers with the 33 steers and 3 cows (Missouri animals) and the correlation of the composition with age in months*

Y	N=33 steers, Missouri					
	Mean	Standard error of mean (±)	Standard deviation (±)	r_{xy}	b_{yx}	S_{yx} (±)
Empty body:	*Percent*					
Moisture	71.663	0.179	1.045	−0.764	−0.06337	0.840
Ash	5.609	.102	.591	+.533	+.02037	.508
Crude protein	21.970	.150	.870	+.677	+.03804	.649
Carcass:						
Moisture	71.891	.180	1.047	−.606	−.04494	.928
Ash	6.384	.130	.759	+.516	+.02534	.660
Crude protein	21.724	.130	.758	+.400	+.01961	.706
Edible portion of carcass:						
Moisture	77.851	.119	.692	−.284	−.01273	.674
Ash	1.066	.011	.063	−.484	−.00196	.056
Crude protein	21.083	.118	.692	+.329	+.01469	.663

Y	N=33 steers and 3 cows=36 animals, Missouri					
	Mean	Standard error of mean (±)	Standard deviation (±)	r_{xy}	b_{yx}	S_{yx} (±)
Empty body:	*Percent*					
Moisture	71.662	0.025	1.245	−0.480	−0.02456	1.107
Ash	5.637	.096	.580	+.431	+.01027	.530
Crude protein	21.951	.138	.830	+.367	+.01264	.790
Carcass:						
Moisture	71.665	.220	1.337	−.740	−.04072	.910
Ash	6.491	.134	.813	+.617	+.02064	.649
Crude protein	21.843	.136	.829	+.589	+.02008	.679
Edible portion of carcass:						
Moisture	77.721	.130	.795	−.572	−.01870	.661
Ash	1.069	.010	.061	−.142	−.00036	.061
Crude protein	21.210	.129	.789	+.588	+.01906	.647

X=Age in months (N=33, mean=22.818, standard deviation=15.282; N=36, mean=28.361, standard deviation=24.003).
r_{xy}=Correlation coefficient.
b_{yx}=Regression coefficient of composition on age in months.
S_{yx}=Standard error of estimate of composition.

TABLE 9.—*Mean composition and composition by regression on age in months for the empty body, carcass, and edible portion of carcass on ether extract-free basis*

Item	For 33 Steers, Missouri							
	Mean [1]	Standard (±) deviation	Composition by regression on age (months)					Standard error of estimate (±)
			10	20	30	40	50	
Empty body:	*Percent*		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
Moisture	71.663	1.045	72.475	71.841	71.208	70.574	69.941	0.840
Ash	5.609	.591	5.348	5.552	5.755	5.959	6.163	.508
Crude protein	21.970	.870	21.483	21.863	22.243	22.624	23.004	.649
Carcass:								
Moisture	71.891	1.047	72.467	72.017	71.568	71.119	70.669	.928
Ash	6.384	.759	6.059	6.313	6.566	6.819	7.073	.660
Crude protein	21.724	.758	21.473	21.669	21.865	22.061	22.257	.706
Edible portion of carcass:								
Moisture	77.851	.692	78.014	77.887	77.760	77.632	77.505	.674
Ash	1.066	.063	1.091	1.072	1.052	1.032	1.013	.056
Crude protein	21.083	.692	20.895	21.042	21.189	21.335	21.482	.663

[1] Mean composition at mean age of 22.818 months.

TABLE 9.—*Mean composition and composition by regression on age in months for the empty body, carcass, and edible portion of carcass on other extract-free basis*—Continued.

Item	For 33 steers and 3 cows (36 animals), Missouri							
	Mean [1]	Standard deviation (±)	Composition by regression on age (months)					Standard error of estimate (±)
			10	20	30	40	50	
Empty body:	*Percent*		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
Moisture	71.662	1.245	72.113	71.867	71.622	71.376	71.131	1.107
Ash	5.637	.580	5.449	5.551	5.654	5.757	5.859	.530
Crude protein	21.951	.838	21.719	21.845	21.972	22.098	22.225	.790
Carcass:								
Moisture	71.665	1.337	72.413	72.005	71.598	71.191	70.784	.910
Ash	6.491	.813	6.112	6.319	6.525	6.731	6.938	.649
Crude protein	21.843	.829	21.475	21.675	21.876	22.077	22.277	.679
Edible portion of carcass:								
Moisture	77.721	.795	78.064	77.877	77.690	77.503	77.316	.661
Ash	1.069	.061	1.075	1.072	1.068	1.065	1.061	.061
Crude protein	21.210	.789	20.861	21.051	21.241	21.432	21.622	.647

[1] Mean composition at mean age of 28.361 months.

The slightly lower standard errors of estimate (table 8) indicate the use of the average composition on the ether extract-free basis by regression for the 33 steers as practical constants for the ages indicated for the empty body, and that for the 36 steers and cows for the carcass and edible portion of the carcass (table 9). The use of these values should be preferred to the use of the mean values of the ether extract-free composition as practical constants as they take into account the small influence of age.

The lack of conformity of the three aged Jersey cows in the case of the empty body apparently is due to the maintenance of a high moisture content in the offal. There is a possibility that this may be related to sex, pregnancy, and lactation.

ESTIMATION OF ASH FROM ETHER EXTRACT IN EDIBLE PORTIONS

The observation that age does not significantly influence the percentage of ash in the ether extract-free edible portion of the carcass, indicated by the low standard deviation, low regression coefficient, and the similarity between the standard deviation and standard error of estimate (table 8), suggests that in the analysis of the edible portions the percentage of ash may be estimated as accurately from the percentage of ether extract as the ash may be determined by laboratory means. The summary analysis of the percentage of ash in five portions not containing bone and the relations between the percentages of ash and ether extract in these portions derived from the mean percentages of ash on the ether extract-free basis, assuming a uniform regression for infiltration of ether extract from 0 to 100 percent, show a similarity in those portions containing lean (table 10). The summary relations for the three edible portions and for the five portions containing lean were identical. However, there is a larger mean percentage of ash in the ether extract-free fat or separable adipose tissue of the 9–11 rib cut than in the edible portions containing lean. The difference is larger than may possibly be accounted for by error in analysis and accidental inclusion of some bone in separating the fat.

TABLE 10.—*Relation between percentage of ash and percentage of ether extract in some edible portions derived from the mean percentage of ash on the ether extract-free basis*

Relation No.	Animal portion	*n*	Ash (ether extract-free basis)					Equation [1]
			Lowest	Highest	Range	Standard deviation (±)	Mean	
			Percent	*Percent*			*Percent*	
1	Edible carcass	36	0.94	1.23	0.29	0.061	1.069	$Y=1.069-0.01069\ X$
2	Edible wholesale rib	36	.91	1.24	.33	.071	1.069	$Y=1.069-.01069\ X$
3	Edible 9–11 rib	56	1.03	1.16	.13	.029	1.098	$Y=1.098-.01098\ X$
4	Eye muscle, 9–11 rib	56	1.04	1.20	.16	.029	1.087	$Y=1.087-.01087\ X$
5	Other lean, 9–11 rib	56	.96	1.16	.20	.036	1.080	$Y=1.080-.01080\ X$
6	Fat, 9–11 rib	56	1.05	1.73	.68	.163	1.315	$Y=1.315-.01315\ X$
7	Edible portions (1, 2, 3)	128	.91	1.24	.33	.054	1.082	$Y=1.082-.01082\ X$
8	Portions with lean (1, 2, 3, 4, 5)	240	.91	1.24	.33	.045	1.082	$Y=1.082-.01082\ X$

[1] X=Percent ether extract; Y=percent ash.

The relations derived by correlation analysis (table 11) are similar to those derived from the mean percentages of ash (table 10), and practical results calculated from them vary but little except in the case of the fat of the 9–11 rib cut. The standard errors of estimate are approximately the variation usually accepted on the duplication of analysis. If used practically, it is suggested that relation 8, table 11, be used for edible portions containing lean, and relation 6, table 11, be used for fat or separable adipose tissue. The data used do not indicate possibility of variation in the percentage of ash in the edible portion of the various cuts and in the adipose tissue of the various parts of the carcass.

ESTIMATION OF FATNESS

The fundamental measure of fatness is the percentage of ether extract or true chemical fat. It is evident from the data presented that there is a possibility of predicting or estimating the percentage of ether extract in the empty body of cattle by using as an indicator the percentage of ether extract or separable fat in the whole and edible portions of the wholesale or 9–11 rib cuts.

The relations for estimation from the percentage of ether extract and fat of the whole and edible portion of the wholesale rib cut were calculated directly from the compositional data for the 36 Missouri animals (relations 1, 2, 5, 7, 11, 12, 15, 17, 21, 22, 25, and 27, table 12). The correlation coefficients and the standard errors of estimate were calculated for these relations.

The Y intercepts for the equations when using the separable fat of the whole and edible portion of the wholesale rib cut are relatively large (relations 5, 7, 15, 17, 25, and 27, table 12). For this reason similar relations were derived indirectly by combination of the relations between the fat in the wholesale rib cuts and the fat in the empty body, carcass, and edible carcass with the relations between the fat and ether extract in the empty body, carcass, and edible portion of the carcass (relations 6, 8, 16, 18, 26, and 28, table 12). The relations combined in the derivations are indicated in the footnote to table 12.

TABLE 11.—*Relation between the percentage of ash and the percentage of ether extract in some edible portions determined by correlation analysis*

Relation No.	Animal portion	n	X (ether extract)					Y (ash)					Correlation coefficient r_{xy}	Regression of Y on X[1]	$S_{yx}(\pm)$%
			Lowest	Highest	Range	Standard deviation (±)	Mean	Lowest	Highest	Range	Standard deviation (±)	Mean			
			Percent	*Percent*			*Percent*	*Percent*	*Percent*			*Percent*			
1	Edible carcass	36	1.89	53.32	51.43	13.71	20.11	0.48	1.16	0.68	0.43	0.86	−0.953	$Y=1.0910-0.01164\,X$	0.050
2	Edible wholesale rib	36	2.09	59.82	57.73	15.66	20.08	.41	1.16	.75	.19	.86	−.957	$Y=1.0921-.01166\,X$	.055
3	Edible 9–11 rib	56	1.84	48.58	46.74	12.57	23.13	.57	1.09	.52	.13	.84	−.985	$Y=1.0844-.01048\,X$	.022
4	Eye muscle, 9–11 rib	56	.39	6.74	6.35	1.53	2.60	1.00	1.16	.16	.03	1.06	−.485	$Y=1.0838-.00995\,X$	.027
5	Other lean, 9–11 rib	56	1.77	21.28	19.51	4.75	10.53	.83	1.10	.27	.07	.97	−.904	$Y=1.0966-.01219\,X$	.027
6	Fat, 9–11 rib	56	16.18	88.86	72.68	19.32	69.75	.15	1.02	.87	.22	.38	−.977	$Y=1.1726-.01131\,X$	.047
7	Edible portions (1, 2, 3)	128	1.84	59.82	57.98	13.12	21.42	.41	1.16	.75	.16	.85	−.961	$Y=1.0897-.01115\,X$	.044
8	Portions with lean (1, 2, 3, 4, 5)	240	.39	59.82	59.43	14.02	14.49	.41	1.16	.75	.15	.94	−.968	$Y=1.0960-.01112\,X$	.037

[1] X=Percent ether extract; y=percent ash.

The relations so derived had lower Y intercepts and very similar regression coefficients as compared to the relations calculated from the experimental data.

TABLE 12.—*Relations of the ether extract in the empty body, carcass, and edible portion of the carcass to the chemical and physical fat in the whole and edible portion of the wholesale and 9-11 rib cuts*

Relation No.	X	Y	n [1]	r_{xy}	Regression of Y on X	
					Equation	$Y_{X} \pm$
1	Ether extract, wholesale rib.	Ether extract, empty body.	36	0.992	$Y=0.79149\ X+2.20772$	1.311
2	Ether extract, edible wholesale rib.	do	36	.989	$Y=.67617\ X+4.56741$	1.532
3	Ether extract, 9-11 rib	do	(1)	.983	$Y=.66234\ X+4.05099$	
4	Ether extract, edible 9-11 rib.	do	(2)	.983	$Y=.57564\ X+4.94311$	
5	Fat, wholesale rib	do	36	.976	$Y=.79457\ X+8.11691$	2.327
6	do	do	(3)	.969	$Y=.77865\ X+6.63270$	
7	Fat, edible wholesale rib	do	36	.992	$Y=.69751\ X+7.35292$	2.207
8	do	do	(4)	.966	$Y=.67466\ X+5.87784$	
9	Fat, 9-11 rib	do	(5)	.981	$Y=.72534\ X+4.82360$	
10	Fat, edible 9-11 rib	do	(6)	.977	$Y=.62885\ X+3.95249$	
11	Ether extract, wholesale rib.	Ether extract, carcass	36	.994	$Y=.88736\ X+2.58567$	1.217
12	Ether extract, edible wholesale rib.	do	36	.992	$Y=.75817\ X+5.22898$	1.493
13	Ether extract, 9-11 rib	do	(7)	.983	$Y=.76289\ X+5.15647$	
14	Ether extract, edible 9-11 rib.	do	(8)	.983	$Y=.66290\ X+6.18682$	
15	Fat, wholesale rib	do	36	.980	$Y=.89249\ X+9.18945$	2.370
16	do	do	(9)	.976	$Y=.88942\ X+7.87455$	
17	Fat, edible wholesale rib	do	36	.983	$Y=.78381\ X+8.32603$	2.187
18	do	do	(10)	.974	$Y=.77212\ X+6.98505$	
19	Fat, 9-11 rib	do	(11)	.979	$Y=.83315\ X+6.08894$	
20	Fat, edible 9-11 rib	do	(12)	.976	$Y=.72365\ X+5.05824$	
21	Ether extract, wholesale rib.	Ether extract, edible carcass.	36	.993	$Y=1.01546\ X-.33524$	1.641
22	Ether extract, edible wholesale rib.	do	36	.994	$Y=.87116\ X+2.61859$	1.456
23	Ether extract, 9-11 rib	do	(13)	.983	$Y=.89098\ X+2.19829$	
24	Ether extract, edible 9-11 rib.	do	(14)	.983	$Y=.77976\ X+3.40164$	
25	Fat, wholesale rib	do	36	.980	$Y=1.02339\ X+7.19589$	2.708
26	do	do	(15)	.973	$Y=1.02829\ X+5.62564$	
27	Fat, edible wholesale rib	do	36	.984	$Y=.89974\ X+6.19082$	2.422
28	do	do	(16)	.974	$Y=.89476\ X+4.55921$	
29	Fat, 9-11 rib	do	(17)	.977	$Y=.97803\ X+3.32361$	
30	Fat, edible 9-11 rib	do	(18)	.977	$Y=.85136\ X+2.07101$	

[1] Parentheses indicate derived relations, see text.

Relations derived by combination of 2 other relations. Correlation coefficients calculated as square root of the product of the regression coefficients of derived relations.

Relations combined: (1) 8 and 1, table 5; (2) 11 and 1, table 5; (3) 5, table 3, and 1, table 5; (4) 6, table 3, and 1, table 5; (5) 7, table 3, and 1, table 5; (6) 8, table 3, and 1, table 5; (7) 9 and 2, table 5; (8) 12 and 2, table 5; (9) 15, table 3, and 2, table 5; (10) 16, table 3, and 2, table 5; (11) 17, table 3, and 2, table 5; (12) 18, table 3 and 2, table 5; (13) 10 and 3, table 5; (14) 13 and 3, table 5; (15) 25, table 3, and 3, table 5; (16) 26, table 3, and 3, table 5; (17) 27, table 3, and 3, table 5; (18) 28, table 3, and 3, table 5.

It was not possible to calculate directly the relations between the fat and ether extract of the whole and edible portion of the 9–11 rib cut and the ether extract of the empty body, carcass, and edible portion of the carcass as no analyses were made to give the chemical composition of the 56 North Dakota steers. However, relations were derived indirectly, by using the relations calculated between the percentage of ether extract and the percentage of fat in the empty body, carcass, and edible carcass from the experimental data for the 36 Missouri animals and the relations calculated between the ether extract in the whole and edible portion of the 9–11 rib cut and the fat

in the empty body, carcass, and edible carcass from the experimental data for the 56 North Dakota steers (relations 3, 4, 9, 10, 13, 14, 19, 20, 23, 24, 29, and 30, table 12). The correlation coefficients were calculated as the square root of the product of the regression coefficients of the two regression equations derived in each case.

The procedure used in the indirect derivation of the relations from the two sets of data does not yield "least-square" values for these statistics. It can be shown, however, that under certain conditions this procedure will yield regression constants and correlation coefficients closely approximating those which would have been obtained by the method of least squares had the data been complete. These conditions require that the regression coefficients of the two sets of data be representative of the population and that the correlation coefficients for both sets of data be high. As the animals used may be considered representative of the population and the correlation coefficients for the two sets of data used in each case in obtaining the derived relations were very high, the derived relations and coefficients are considered very close approximations. In subsequent discussion the derived statistics will be treated as least-square values. No method was found for estimating the standard errors of estimate for the derived relations.

The standard errors of estimate and prediction value of the derived relations should be relatively satisfactory since those of the relations from which they were derived were reasonably satisfactory. Tests on additional data showed closer agreement with experimentally determined percentages of ether extract in the three gross portions for values estimated by use of the derived 9–11 rib cut relations than for values estimated by use of the directly calculated wholesale rib cut relations.

The correlation coefficients are all extremely high. For the estimation of the ether extract in the gross portions, the correlations coefficients are in general slightly higher for the ether extract than for the fat relations of the several rib cuts. In the case of the ether extract in the wholesale rib cuts, on the basis of standard errors of estimate, the whole portion appears to be the better indicator of the percentage of ether extract in the empty body and carcass, but for the edible portion of the carcass the edible portion of the wholesale rib cut is the better.

There are considerable variations in the Y intercepts, indicating considerable variation in the percentage of ether extract in the gross portions for zero values in the ether extract and fat groups of indicators. Zero fat content must not be confused as indicating zero ether extract content. Some ether extract is always present when no separable fat is present in the rib cut. This is particularly true in the whole portions containing bone on account of the marrow.

WORK METHODS AND APPLICATION OF SELECTED RELATIONS

In animal feeding trials where more detailed estimates of performance are desirable or needed than the change in live weight, a combination of growth and fattening, and the relative fatness as roughly indicated by the dressing percentages, it is suggested that the fatness and composition of the empty body and carcass be esti-

mated from the composition of the 9–11 rib cut. For this procedure it is necessary to obtain the weights of the empty body and warm carcass and the wholesale rib cut for analysis.

The empty body weight may easily be obtained by deducting the weight of the digestive contents from the slaughter live weight. The weight of the digestive contents may be obtained as the difference between the gross and net weight of the digestive organs, stomachs, intestines, and urinary bladder as they are removed from the animal on the slaughter floor. The warm carcass weight is obtained before the carcass is washed and shrouded.

In order to relate the data back to the pasture or feed-lot live weight the loss from this weight to the slaughter live weight must be noted. This loss and the digestive contents give the total reduction from the pasture or feed-lot live weight to the empty-body weight.

For the physical and chemical analysis of the indicator cut, the wholesale rib cut (seven ribs), cut according to the standard methods of cutting, is obtained. This method is based on the anatomy of the animal. The side is cut into quarters, leaving one rib (the thirteenth) on the hind quarter. The cut made in separating the wholesale rib cut from the plate is started at the point of intersection on the twelfth rib of a perpendicular erected on the straight line from the tip of the chine bone to the cartilage of the thirteenth rib, where cut in separating the quarters, at a point 61.5 percent of this distance from the tip of the chine bone. The 9–11 rib cut is then taken from the wholesale rib cut crowding the forward ribs with the knife in making the two cuttings. Accurate and uniform care must be taken in the separation of this rib cut into lean, fat, and bone. Accurate weights of the separated portions must be taken. The lean, fat, and bone samples should be analyzed for moisture, ash, protein, and ether extract, of which determinations the ether extract is the most important constituent for consideration. The chemical composition of the whole and edible portion is calculated from the weights and the composition of the portions.

The proposed methods are based on the warm empty body, the warm carcass, and the edible portion of the warm carcass. The cooler shrinkage of the rib cut should be considered as moisture and as proportional to that of the whole carcass. The chemical composition of the 9–11 rib cut and its parts, taken for chemical analysis, should be corrected for this moisture loss, distributing the loss proportionally between the lean, fat, and bone.

For predicting the percentage physical composition of the edible portion of the carcass only the relation between the fat in the edible portion of the 9–11 rib (X) and the fat in the edible portion of the carcass (Y) (relation 28, table 3) (fig. 5) is needed: $Y=0.80161\ X+2.66798$; $r_{xy}=+0.982$; $S_{yx}=\pm 1.748$. The percentage of lean in the edible portion of the carcass may be calculated by using relation 24, table 3, but is more simply obtained as being 100 percent minus the estimated percentage of fat. The results will be the same in either case.

In predicting the percentage physical composition of the carcass only the percentage of bone is needed in addition to the percentage of lean and fat in the edible portion. The percentage of bone in the carcass (Y) is estimated from the percentage of bone in the 9–11 rib cut (X), by using relation 20, table 3 (fig. 6), $Y=0.70750\ X+3.47863$;

$r_{xy}=+0.941$; $S_{yx}=\pm 1.120$. The percentages of the lean and fat in the edible portion of the carcass are then calculated to the percentage of lean and fat in the whole carcass including the bone.

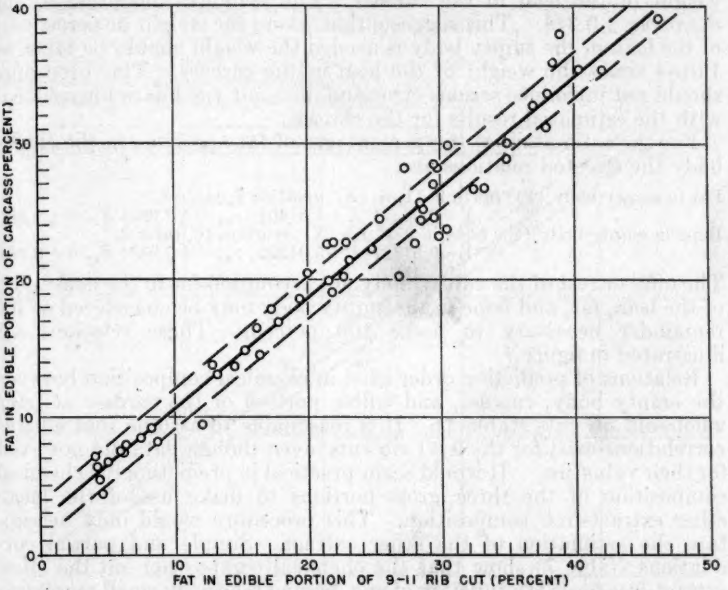

FIGURE 5.—Relation between the percentage of fat in the edible portion of the 9–11 rib cut and the percentage of fat in the edible portion of the carcass. $Y=0.80161\ X+2.66798$; $r_{xy}=+0.982$; $S_{yx}=\pm 1.748$.

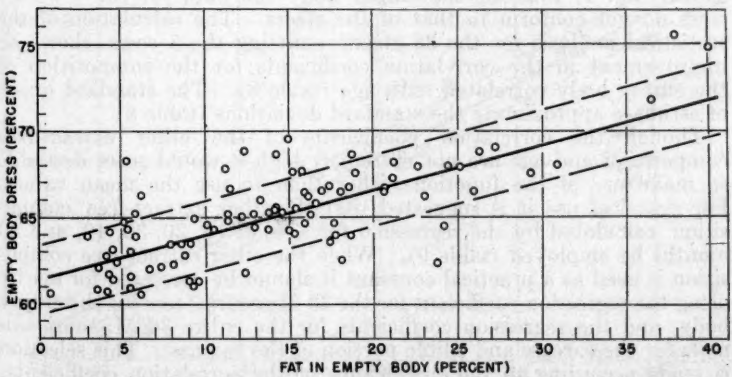

FIGURE 6.—Relation between the percentage of bone in the 9–11 rib cut and the percentage of bone in the carcass. $Y=0.70750\ X\ +\ 3.47863$; $r_{xy}=+0.941$; $S_{yx}=\pm 1.120$.

The correlation coefficient of the lean in the 9–11 rib cut with that in the empty body is not high as compared to other coefficients observed in this study. Perhaps this is because the weight of the lean

in the empty body is not materially increased over that in the carcass. For a series of 58 steers the weights of the lean in the empty body ranged from 1.06 to 2.26 and averaged 1.644 percent more than the weight of the lean in the carcass. The standard deviation of the data was ±0.248. This suggests that where the weight or percentage of the lean in the empty body is needed the weight should be taken as 1.0164 times the weight of the lean in the carcass. This procedure should not introduce serious error and does not yield data inconsistent with the estimated results for the carcass.

For the estimation of the percentages of fat and bone in the empty body the selected relations are:

Fat in empty body (Y); fat in 9–11 rib (X); relation 7, table 3,
$$Y=0.68371\ X+1.61401;\ r_{xy}=+0.985;\ S_{yx}=\pm 1.180.$$
Bone in empty body (Y); bone in 9–11 rib (X); relation 10, table 3,
$$Y=0.51327\ X+5.04322;\ r_{xy}=+0.947;\ S_{yx}=\pm 0.764.$$

The offal or rest of the empty body not accounted for in the definitions of the lean, fat, and bone in the empty body may be considered as the remainder necessary to make 100 percent. These relations are illustrated in figure 7.

Relations of prediction order exist in chemical composition between the empty body, carcass, and edible portion of the carcass and the wholesale rib cuts (table 4). It is reasonable to assume that similar correlations exist for the 9–11 rib cuts even though data did not exist for their valuation. It would seem practical in predicting the chemical composition of the three gross portions to make use of the mean ether extract-free composition. This procedure would only necessitate the estimation of the ether extract. Simple and partial correlations (table 7) show that the chemical composition on the ether extract-free basis is a function of age, having relatively small regression coefficients. There is little significance to the simple and partial correlation of the same composition with fatness (table 7). It is shown (fig. 4) that for the empty body the data for the 3 Jersey cows do not conform to that of the steers. The calculation of the statistical analysis for the 33 steers omitting the 3 cows shows an improvement in the correlation coefficients for the composition of the empty body correlated with age (table 8). The standard errors of estimate approximate the standard deviations (table 8).

Though the correlation coefficients of the ether extract-free composition and age are not extremely high it would seem desirable to make use of the function rather than to use the mean values. For practical use it is suggested that the ether extract-free composition calculated by the regression for ages of 10, 20, 30, 40, and 50 months be employed (table 9). When the ether extract-free composition is used as a practical constant it should be corrected for age by using the regression coefficient for the 33 Missouri steers for the empty body, and the regression coefficients for the entire 36 Missouri animals for the carcass and edible portion of the carcass. This selection is made according to the significance of the correlation coefficients.

If it is not practical to make a chemical analysis of the rib cut and only the physical composition is available the chemical composition may be approximated. This can be done by determining the percentage of fat in the empty body, carcass, and edible portion of the

carcass by the physical analysis as indicated and calculating the percentage of ether extract from the percentage of fat in these gross portions using relations 1, 2, and 3, table 5.

Empty body: Ether extract (Y), fat (X),
$Y=1.06089\ X+3.11131$; $r_{xy}=+0.996$; $S_{yx}=\pm 0.954$.
Carcass: Ether extract (Y), fat (X),
$Y=1.01885\ X+3.76939$; $r_{xy}=+0.994$; $S_{yx}=\pm 1.291$.
Edible portion of carcass: Ether extract (Y), fat (X),
$Y=1.06206\ X-0.76254$; $r_{xy}=+0.994$; $S_{yx}=\pm 1.455$.

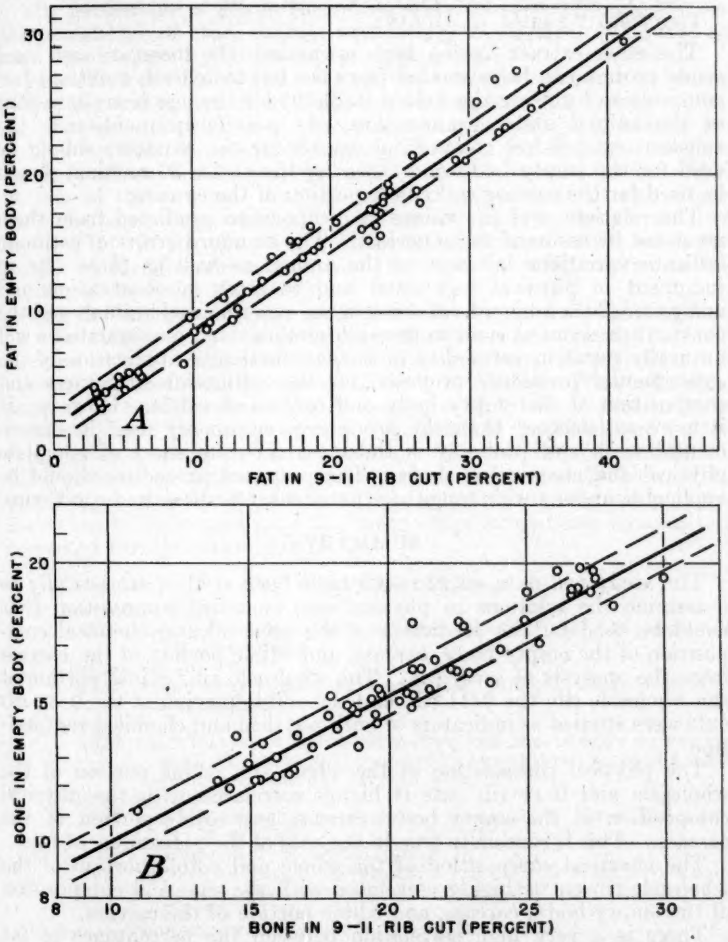

FIGURE 7.—Relations in percentage of fat (A) and bone (B) between the 9–11 rib cut and the empty body. Fat: $Y=0.68371\ X+1.61401$; $r_{xy}=+0.985$; $S_{yx}=+1.180$. Bone: $Y=0.51327\ X+5.04322$; $r_{xy}=+0.947$; $S_{yx}=\pm 0.764$.

However it should introduce less error to estimate the percentages of ether extract in the three gross portions from the determined ether extract in the rib cuts. This procedure is thought the most desirable. The relations suggested for use are:

Ether extract: Empty body (Y), 9–11 rib cut (X), relation 3, table 12,
$Y=0.66234\ X+4.05099$; $r_{xy}=+0.983$.
Ether extract: Carcass (Y), 9–11 rib cut (X), relation 13, table 12,
$Y=0.76289\ X+5.15647$; $r_{xy}=+0.983$.
Ether extract: Edible portion of the carcass (Y), edible portion of the 9–11 rib cut (X), relation 24, table 12,
$Y=0.77976\ X\ 3.40164$; $r_{xy}=+0.983$.

The ether extract having been estimated the moisture ash and crude protein can be estimated from the forecasted ether extract-free composition by using the values (table 9) for the age nearest to that of the animal under examination. As previously mentioned the constant extract-free composition values for the 33 steers should be used for the empty body and those for the entire 36 anmials should be used for the carcass and edible portion of the carcass.

The relations and the values in composition predicted from them must not be assumed to be perfect. The standard errors of estimate indicate variations inherent in the animal as well as those due to judgment in physical separation and to error in observation and analysis. Such inherent variation in the experimental animals and the constant presence of error in research methods and manipulations will naturally result in variability in the satisfaction of application of the experimental procedure proposed for the estimation of fatness and composition of the empty body and carcass of cattle. However it is more satisfactory than the procedures commonly used in experimental work and probably is the most accurate short of complete physical and chemical analysis. The proposed procedure should be applicable under a wide range of experimental facilities and conditions.

SUMMARY

The analytical data on 92 cattle have been studied statistically to determine the relations in physical and chemical composition that could be used for the prediction of the physical and chemical composition of the empty body, carcass, and edible portion of the carcass from the analysis of a rib cut. The wholesale rib, edible portion of the wholesale rib, the 9–11 rib, and the edible portion of the 9–11 rib cuts were studied as indicators of both physical and chemical composition.

The physical composition of the whole and edible portion of the wholesale and 9–11 rib cuts is highly correlated with the physical composition of the empty body, carcass, and edible portion of the carcass. This is especially true in the case of the percentage of fat.

The chemical composition of the whole and edible portion of the wholesale rib cut is highly correlated with the chemical composition of the empty body, carcass, and edible portion of the carcass.

There is a very high correlation between the percentages of fat (separable adipose tissue) and ether extract (true chemical fat) in the several portions of the animal studied.

The percentages of ether extract in the eye muscle, fat, and bone of the 9–11 rib are not considered satisfactory indices of fatness.

The dressing percentage is not a reliable indicator of fatness expressed either as fat or as ether extract.

The chemical composition on the ether extract-free basis is a function of age with small regression coefficient. For some purposes the mean might be considered a practical constant. However, for practical application the small variation with age should be recognized in using the composition on the ether extract-free basis as a means of prediction of the percentages of moisture, ash, and crude protein in the empty body, carcass, and edible portion of the carcass.

The percentage of ash in the edible portions may be predicted from the percentage of ether extract with nearly as satisfactory results as may be obtained by laboratory analysis.

The edible portion of the 9–11 rib cut was selected as an indicator of the physical composition of the edible portion of the carcass. For the physical composition of the carcass the percentage of bone is indicated by the percentage of bone in the 9–11 rib cut, and the percentages of lean and fat calculated from those estimated for the edible portion of the carcass. For the physical composition of the empty body the percentages of fat and bone are indicated by the percentages in the 9–11 rib cut, the weight of the lean taken as 1.0164 times the weight of lean in the carcass, and the "partial offal" taken as the remainder to make 100 percent.

The percentages of ether extract in the empty body and carcass may be indicated by the percentage of ether extract in the 9–11 rib cut and in the edible portion of the carcass from the percentage of ether extract in the edible portion of the 9–11 rib cut. Where chemical analysis is not practical, the percentages of ether extract may be estimated from the percentages of fat estimated or determined for the three gross portions. The correlation between the percentages of fat and ether extract in the same portion are extremely high. The percentages of moisture, ash, and crude protein in the gross portions may then be estimated from the mean ether extract-free composition corrected for variations due to age.

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